



WBS 3.1 - Trigger

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CMS Trigger Project Manager

DOE/NSF Review
May 19, 2003

This talk is available on:

http://hep.wisc.edu/wsmith/cms/Trig_Lehman_Plen03.pdf

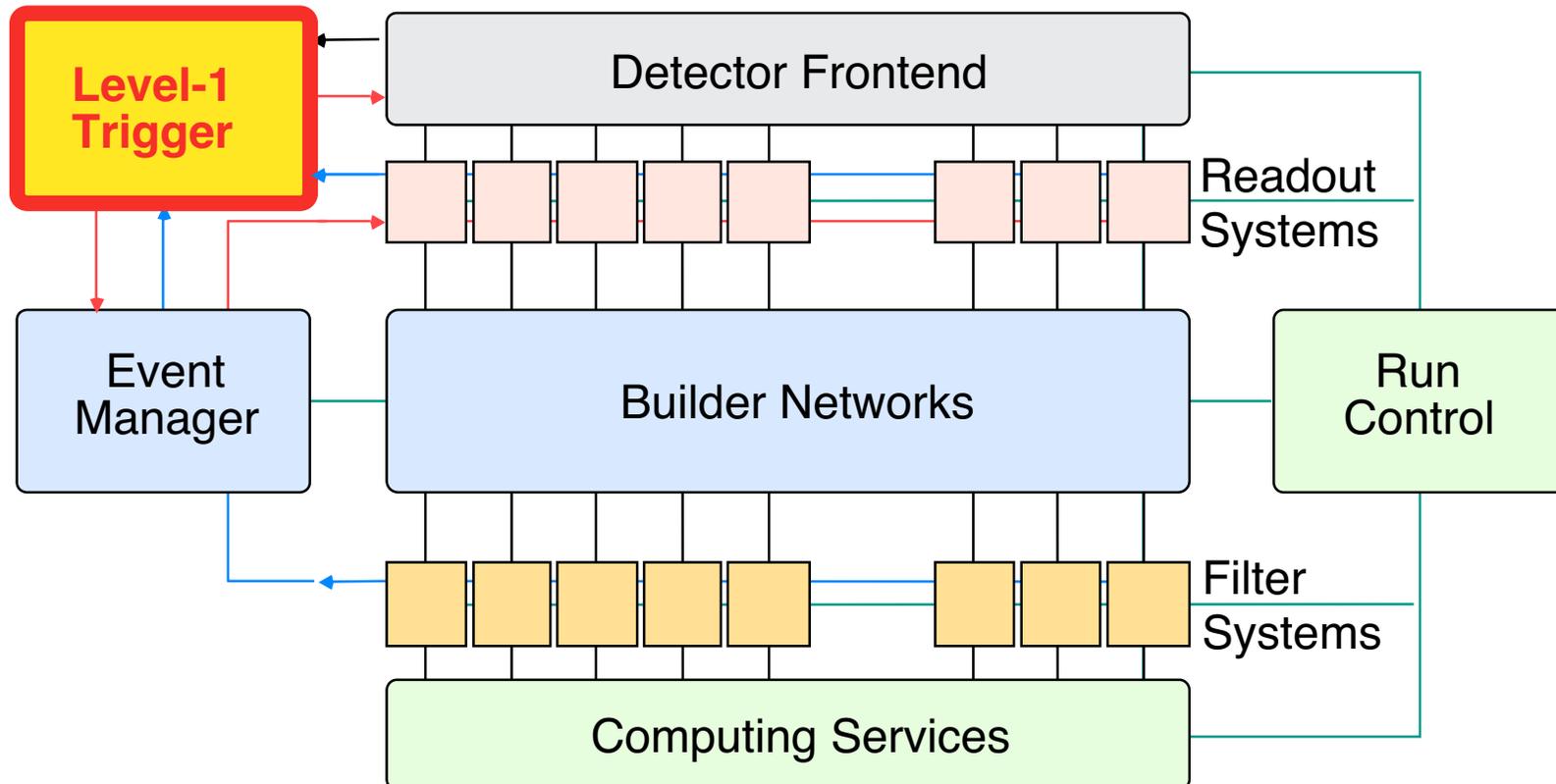


Outline

- **Overview of Calorimeter Trigger**
- **Calorimeter Trigger Status & Plans**
- **Overview of Muon Trigger**
- **Muon Trigger Status & Plans**
- **Cost and Schedule Performance**
- **Transition to M&O**
- **Concerns**
- **Summary and Conclusions**



Trigger & DAQ Systems



Level-1 Trigger Requirements:

- Input: 10^9 events/sec at 40 MHz at full $L = 10^{34}$
- Output: 100 kHz (50 kHz for initial running)
- Latency: 3 μ sec for collection, decision, propagation

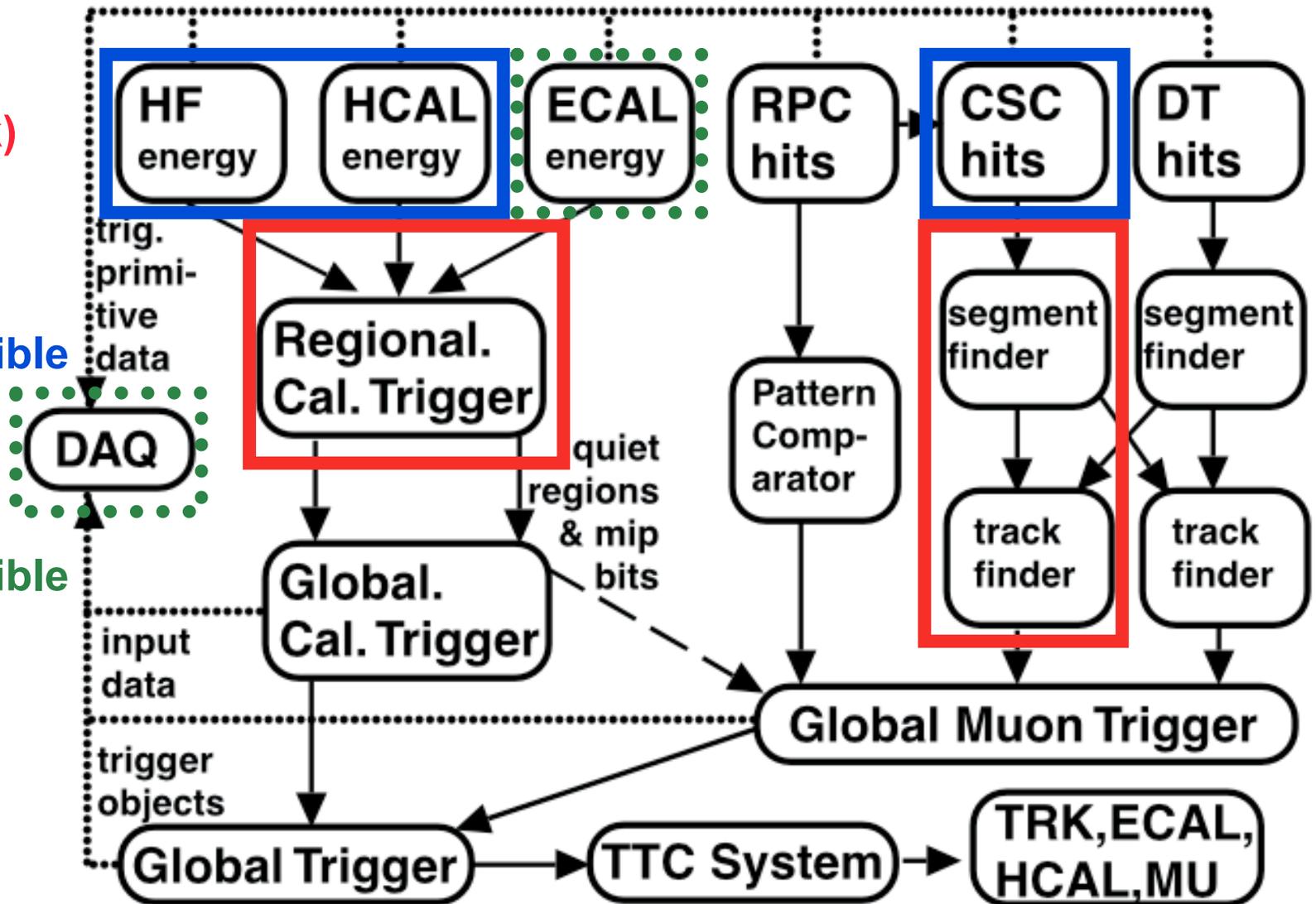


L1 Trigger Hardware Overview

US CMS Trigger (this talk)

US CMS fully responsible

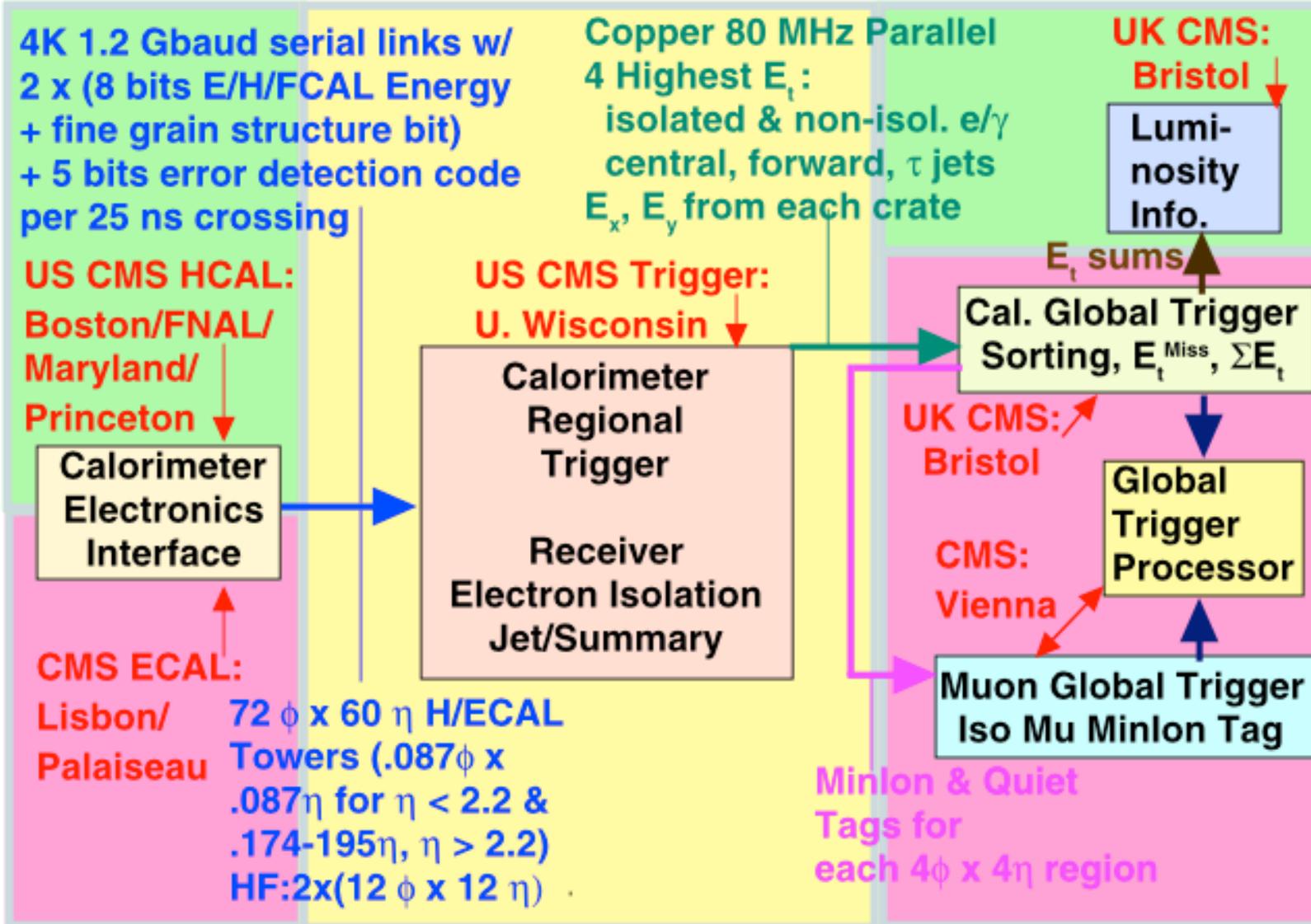
US CMS partially responsible





Calorimeter Trig. Overview

(all located in underground counting room)

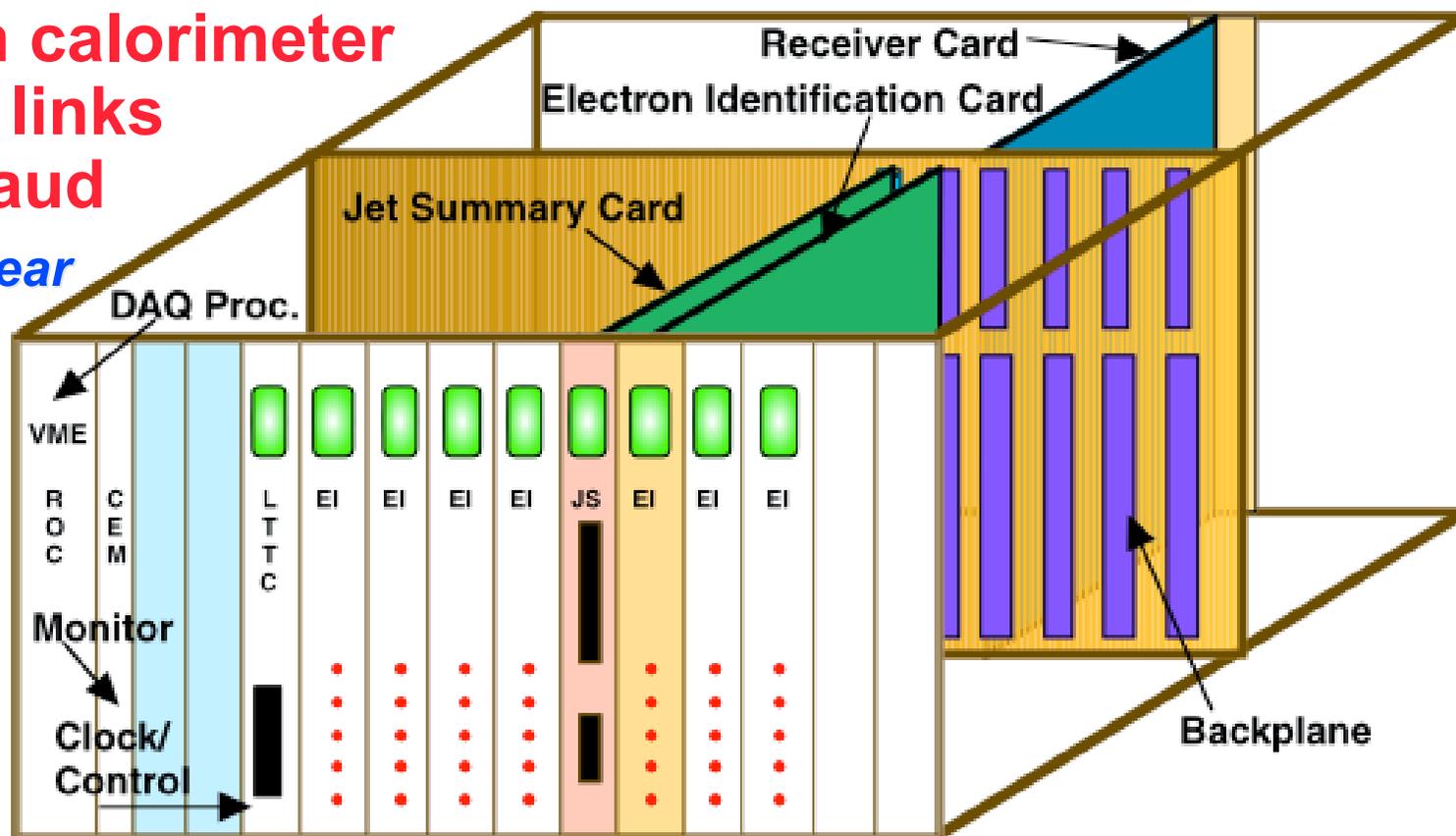




Calorimeter Trigger Crate

**Data from calorimeter
FE on Cu links
@ 1.2 Gbaud**

- Into 126* rear Receiver Cards
- Prototype tested w/ ASICs



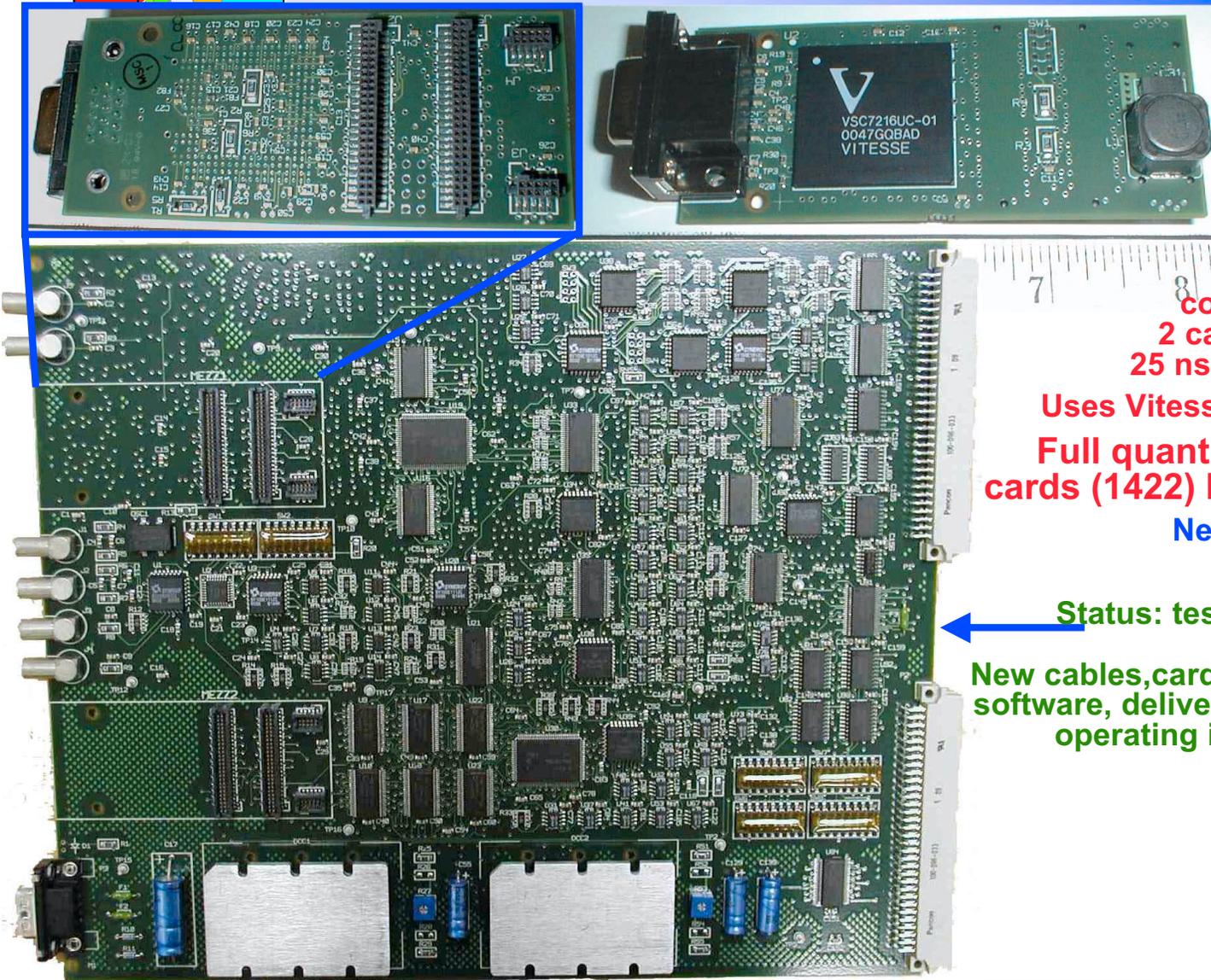
160 MHz point to point backplane (proto. tstd.)

- 18 Clock&Control (proto. tstd.), 126 Electron ID (proto. tstd.), 18 Jet/Summary Cards -- all cards operate @ 160 MHz
- Use 5 Custom Gate-Array 160 MHz GaAs Vitesse Digital ASICs
 - Phase, Adder, Boundary Scan, Electron Isolation, Sort (manufactured)

*Spares
not
included**



Cal. Trig. 4 Gbaud Copper Link Cards & Serial Link Test Card - U. Wisconsin



Compact Mezzanine Cards for each Receiver Card accept

4 x 20 m 1.2-Gbaud copper pairs transmitting 2 cal. tower energies every 25 ns with low cost & power.

Uses Vitesse Link Chips (7216-01).

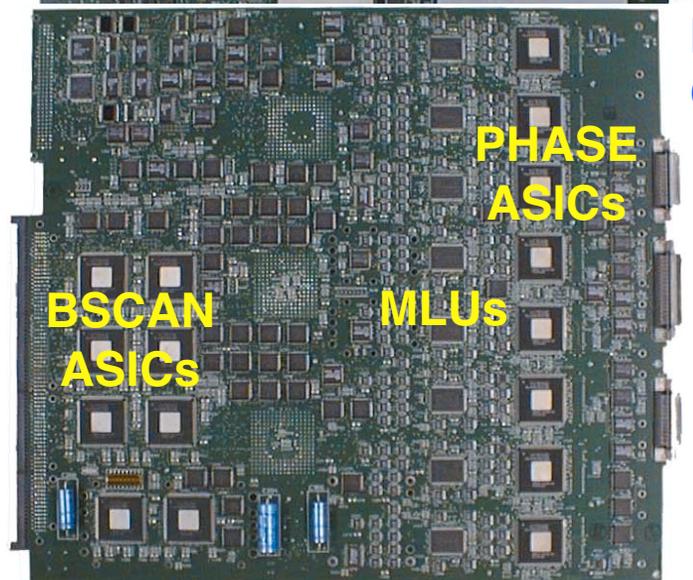
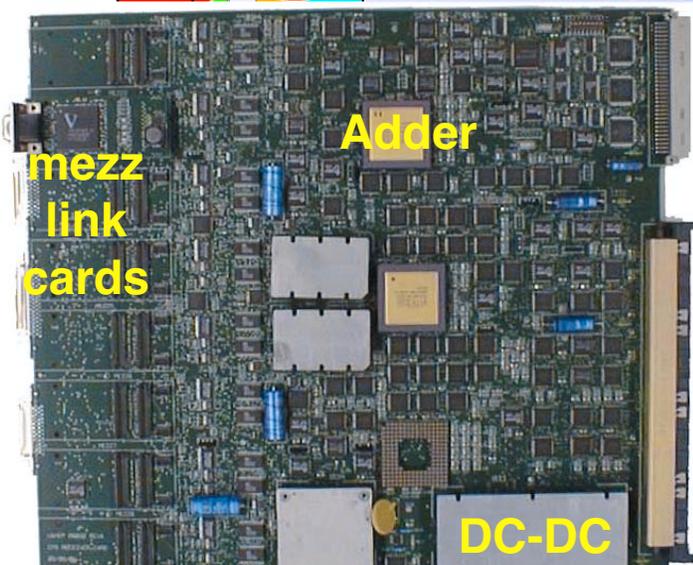
Full quantity of mezzanine link cards (1422) being manufactured.

New Serial Link Test Card

Status: tested and full production manufactured, New cables, cards, 48V PS, and support software, delivered to CERN in Feb '03, operating in ECAL electronics lab stably with no errors



Cal. Trig. Receiver & Electron Isolation Cards - U. Wisconsin



RC & EIC Pre-production Boards validated
Production started

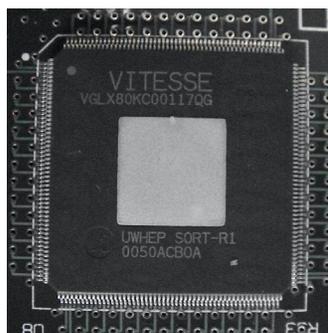
8 RC and EIC Boards being assembled for full crate test before rest of boards are assembled

Production of 5 Custom ASICs complete -- all validated pending EISO full-crate patterns

Receiver Card

Electron Isolation Card

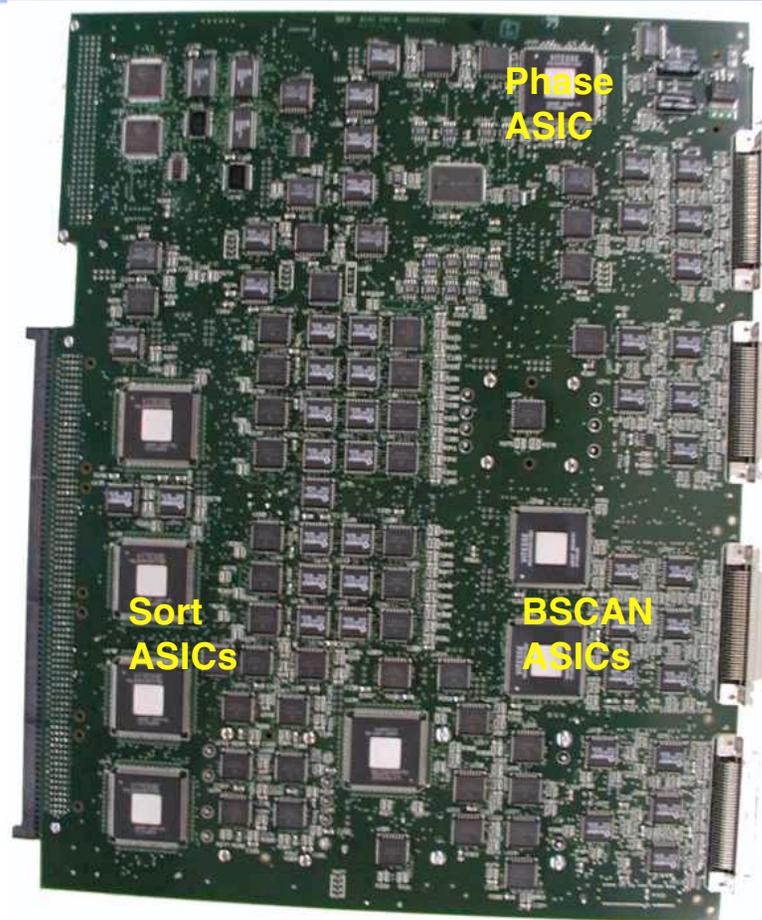
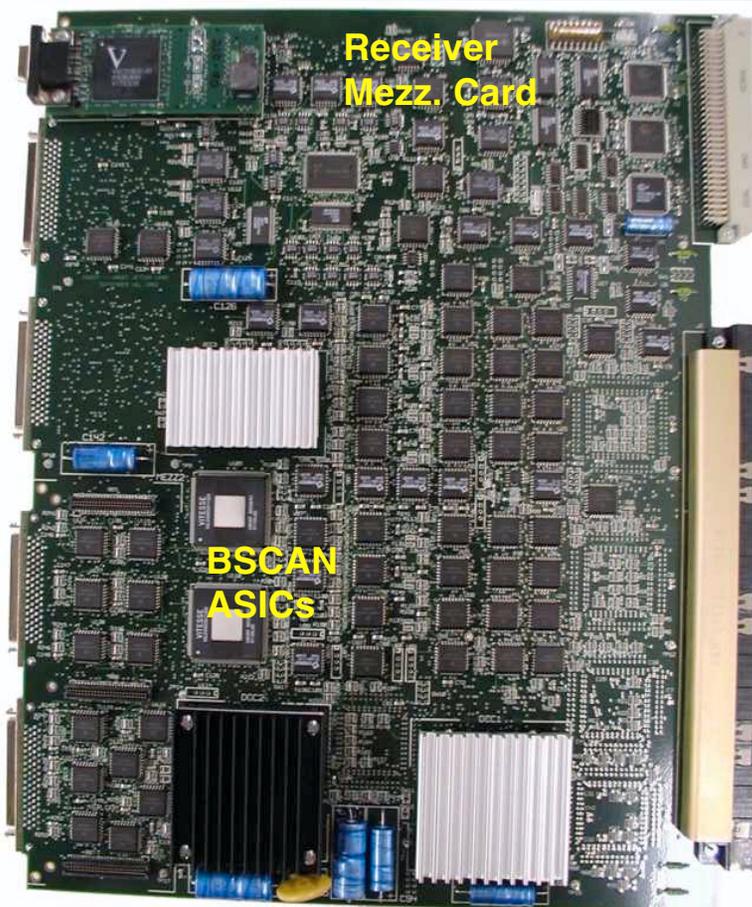
↓
SORT ASIC





Cal. Trig. Jet/Summary Card

- U. Wisconsin



Full function prototype manufactured and under test

- Uses SORT ASICs to find top four e/γ , threshold for muon bits
- Absorbs HF functionality with Rec. Mezz. Card



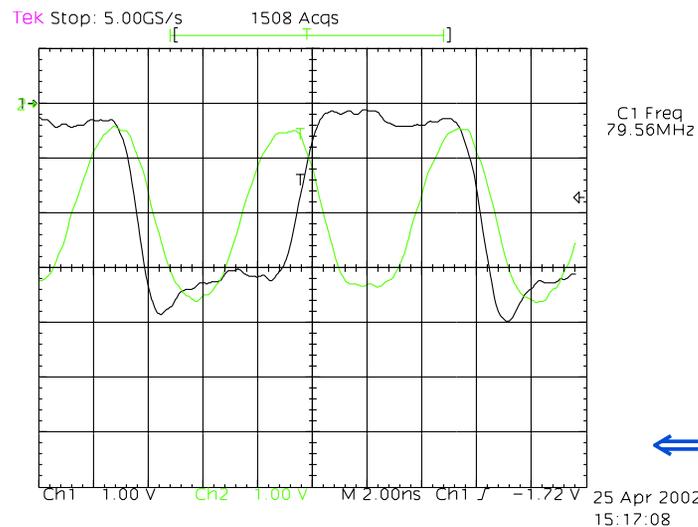
Testing Receiver, Clock, EISO, & Jet/Sum Cards, Crate & Backplane - U. Wisconsin



Rear:
Rec. Card
Loop-back
Cables
for
testing
Data
Sharing

Front:

Clock, EISO, and Jet/Summary Cards
showing original STC and cable to test
HF data transfer to J/S at full speed



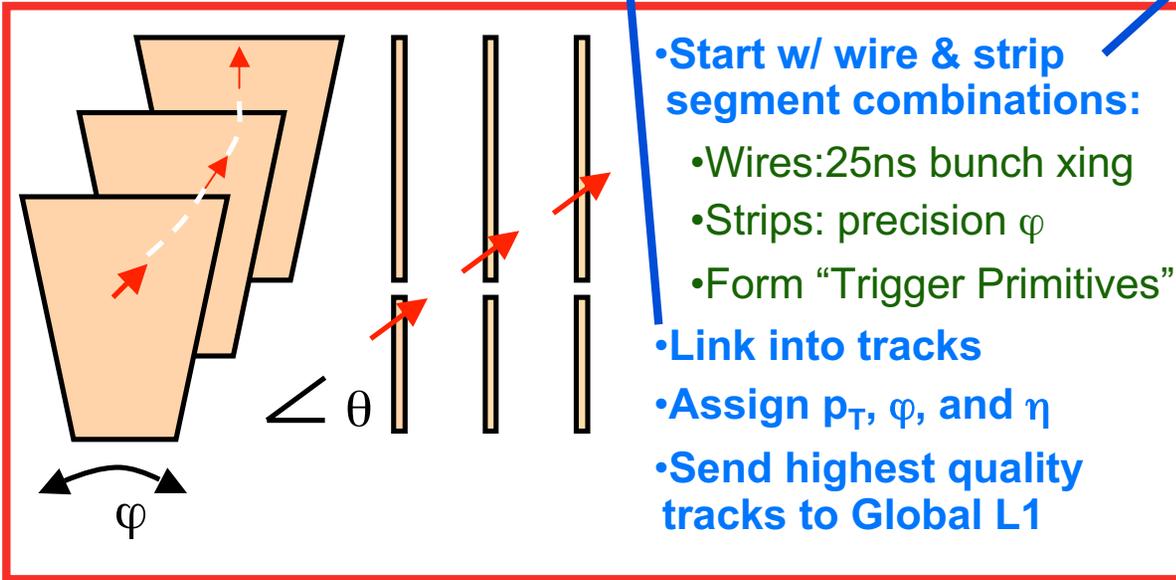
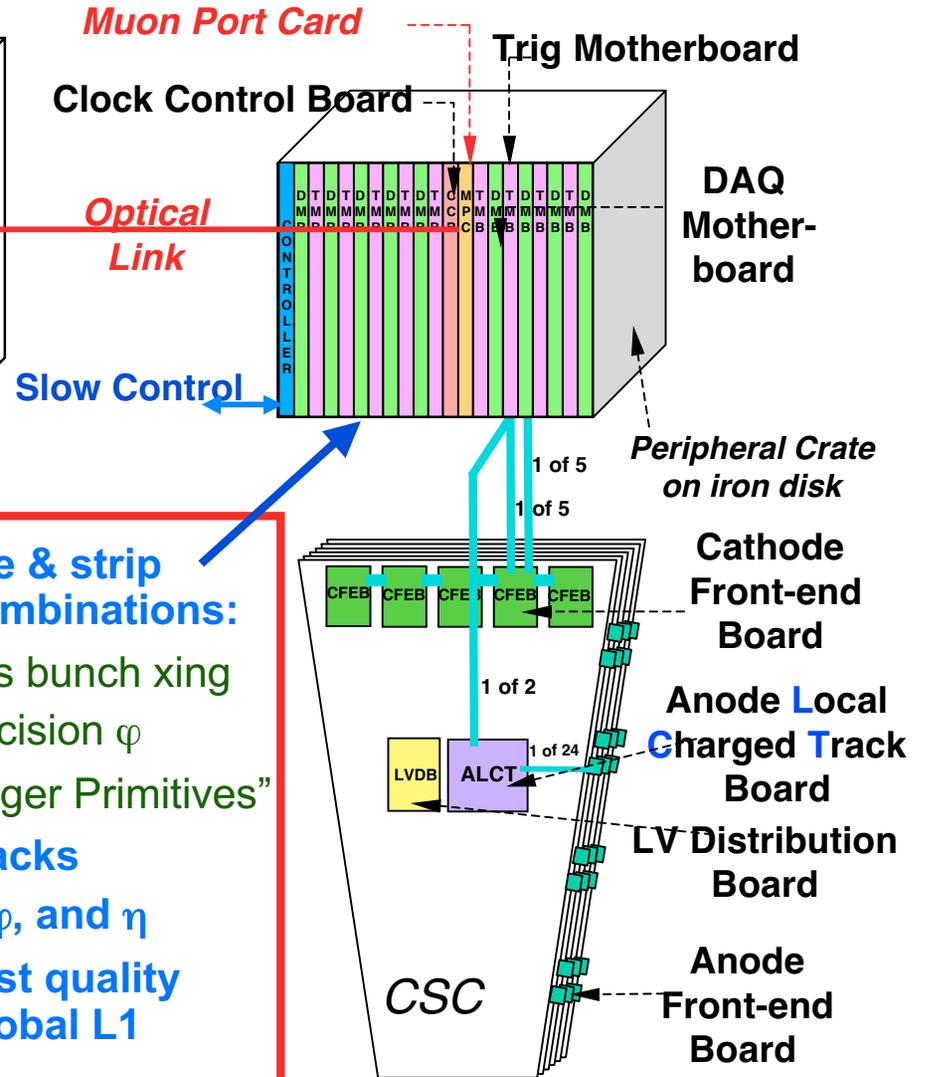
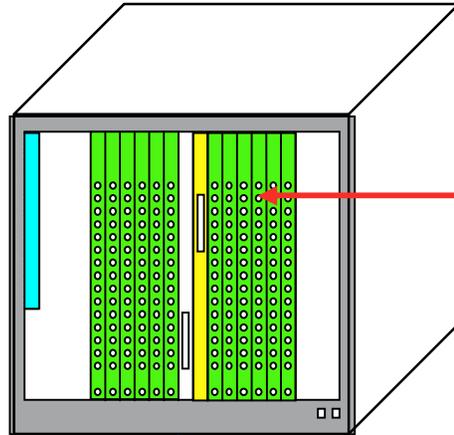
← 160 MHz TTL clock with data into 200 MHz Memories (2 ns scale)



CSC Muon Trigger Overview

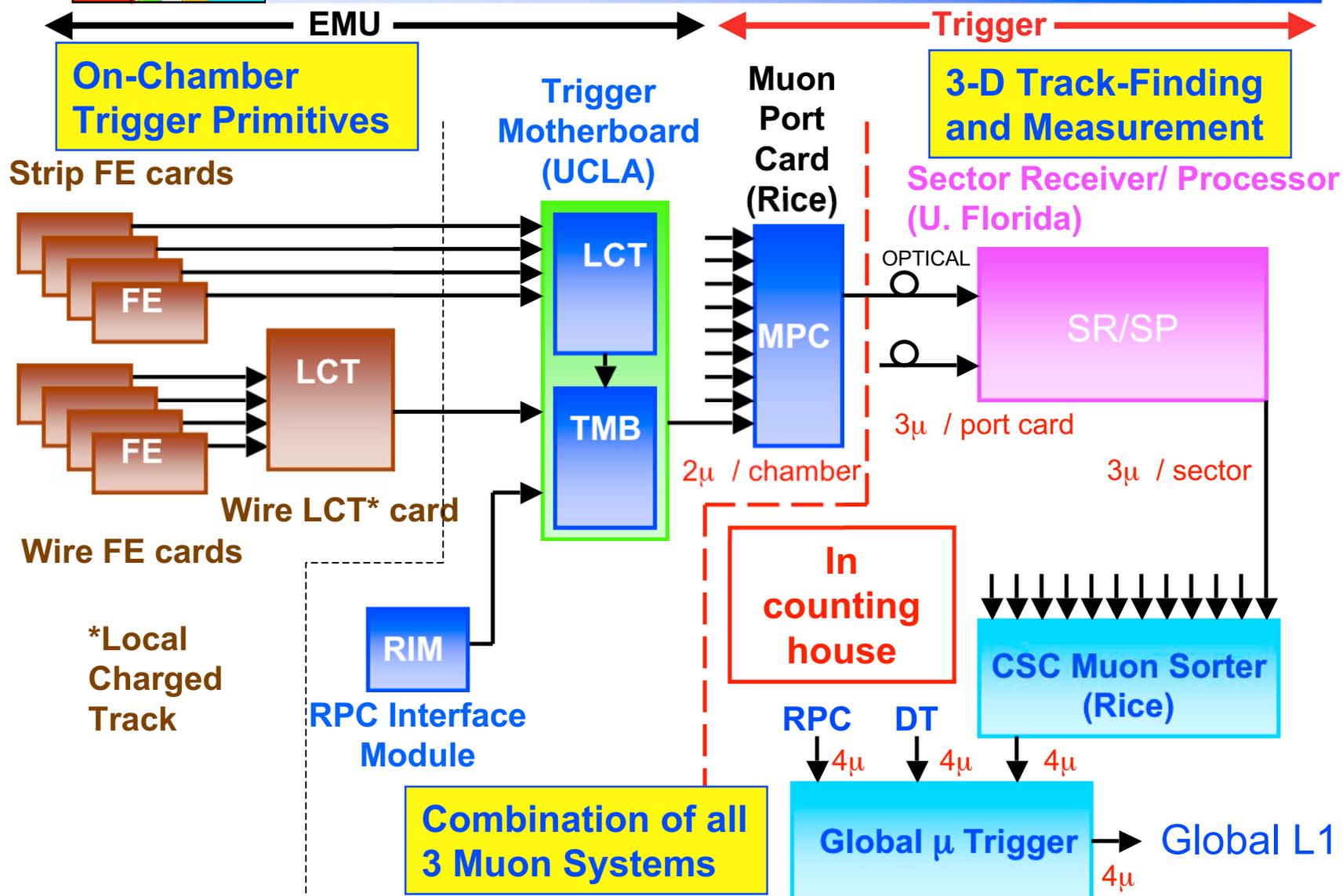
(red = trigger responsibility)

Muon Track-Finder
Crate in underground
counting room:
Sector
Receiver/Processor
+
Muon Sorter
+
Clock & Control Board





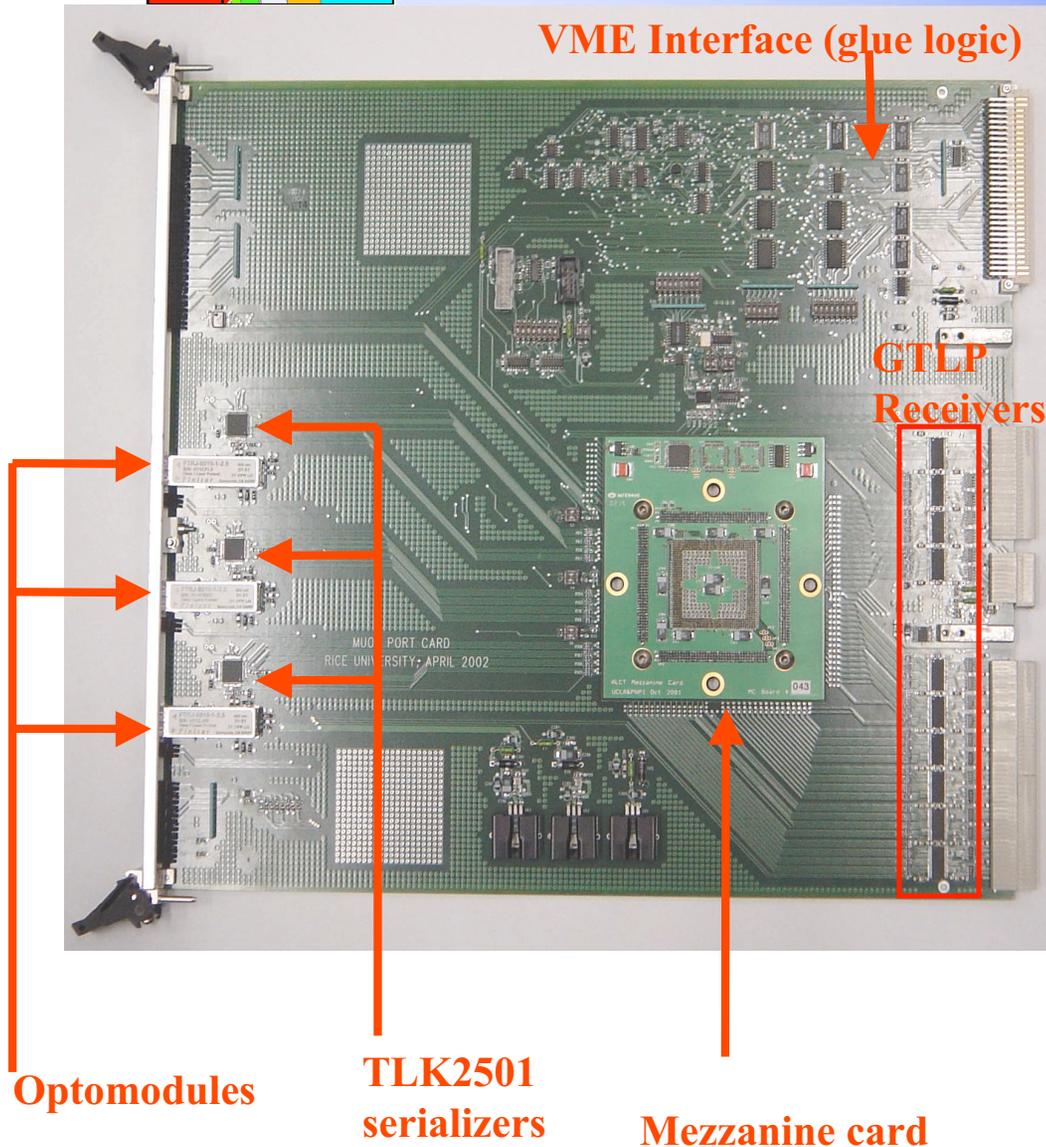
CSC Muon Trigger Scheme





CSC Trigger Muon Port Card

- Rice



6 Boards fabricated and assembled.

Passed stand-alone tests

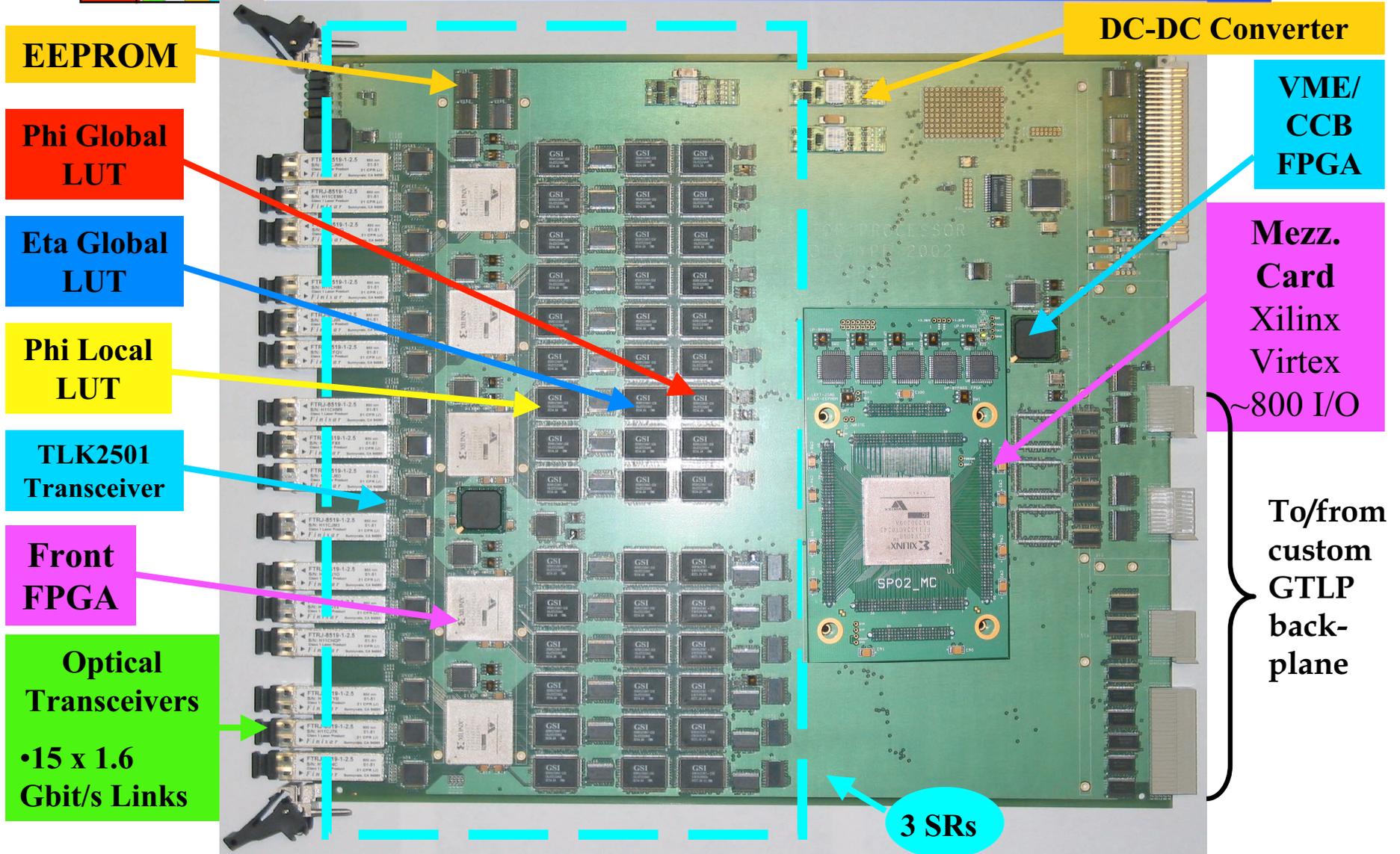
Passed communication tests with Trigger Mother Board

Tests with Track-finder are underway

Tests with time structured test beam on-going at CERN



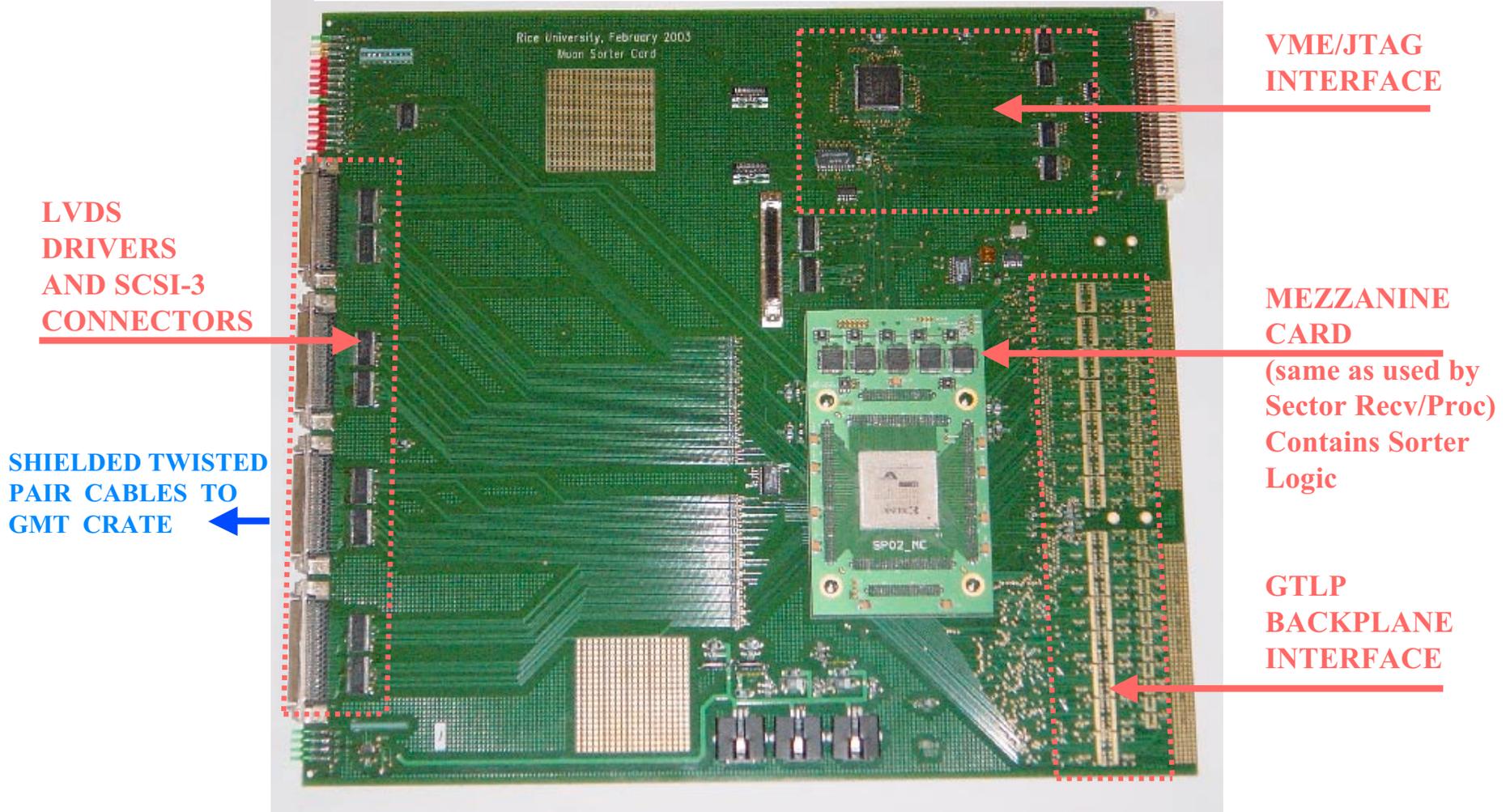
CSC Trigger Sector Receiver/ Processor Under Test - U. Florida





CSC Trigger Muon Sorter

- Rice

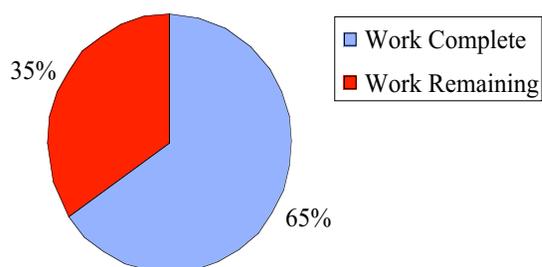


4 Boards in hand, one assembled & under test with dedicated crate, test w/track-finder next

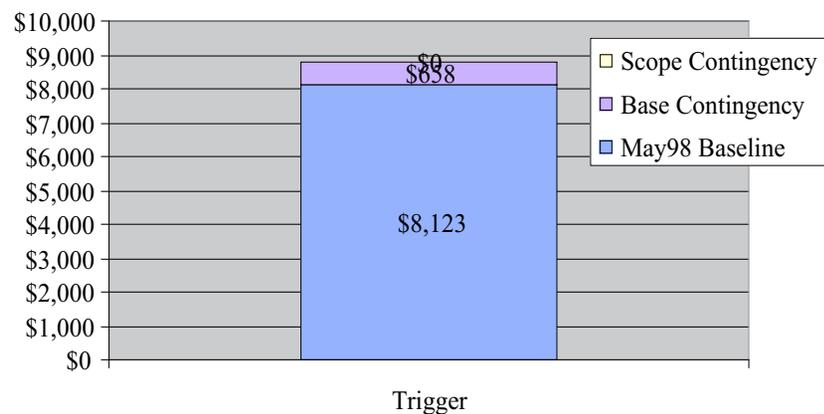


US Trigger Status

US Trigger EAC = \$8,771K AY



US Trigger Contingency Allocation



Pre-production prototypes completed & under test

Production starting

Contingency for production problems, testing difficulties or unanticipated integration tasks



Recent Trigger Milestone Performance (v33)

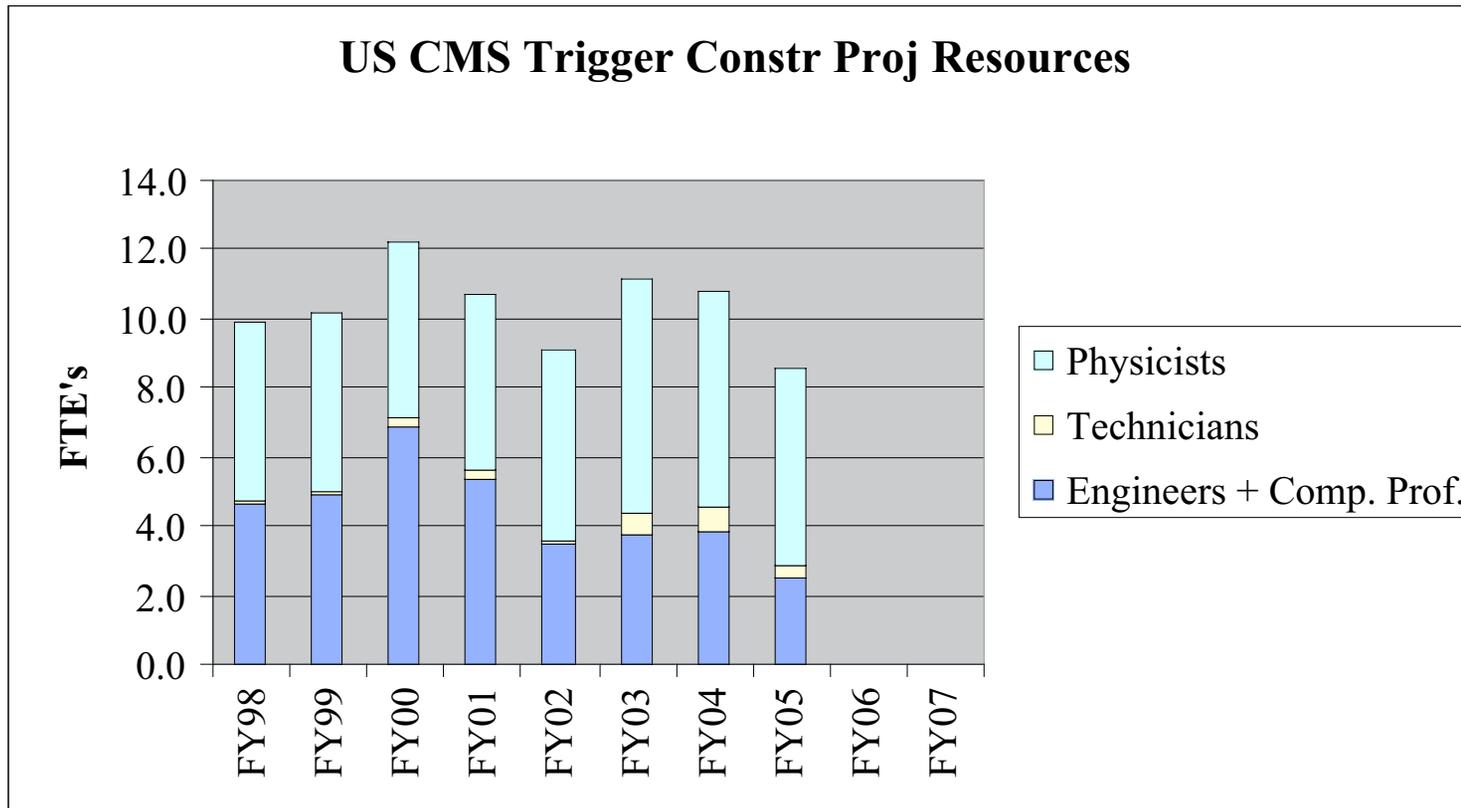
System	Level?	CMS ID	Milestone	v33	Start	Variance	'97	'98	'99	'00	'01	'02	'03	'04	'05
			☐ Trigger Subsystem (WBS 1.3.1)	NA	Nov 30 '98	0 days									
TRIG	ML2	QT-001	Complete Initial Muon, Calorimeter, & Global (M/C/G) Tri	Nov 30 '98	Nov 30 '98	0 days			●						
TRIG	ML3	QT-388	CSC: Muon Port Card Prototype Design (Rice)	May 31 '99	May 31 '99	0 days			●						
TRIG	ML3	QT-390	CSC: SR Prototype Design (UCLA)	Sep 30 '99	Sep 30 '99	0 days			●						
TRIG	ML2	QT-002	Complete Phase 1 Prototype Design	Nov 30 '99	Nov 30 '99	0 days				●					
TRIG	ML3	QT-212	Review of Test of Trigger Primitives - 2 Tower Prototype I	Nov 30 '99	Nov 30 '99	0 days				●					
TRIG	ML3	QT-221	Review of Test of Regional Trigger Prototype Boards and	Nov 30 '99	Nov 30 '99	0 days				●					
TRIG	ML3	QT-231	Design of Final Sort ASIC	Nov 30 '99	Nov 30 '99	0 days				●					
TRIG	ML3	QT-332	TK: SP Prototype Design (Florida)	Nov 30 '99	Nov 30 '99	0 days				●					
TRIG	ML3	QT-389	CSC: Muon Port Card Prototype Delivery (Rice)	Jul 30 '00	Jul 30 '00	0 days					●				
TRIG	ML3	QT-250	Review of Integration of Calorimeter Trigger Prototypes (I	Nov 30 '00	Nov 30 '00	0 days					●				
TRIG	ML1	QT-004	Submit Trigger Technical Design Report (TDR)	Dec 30 '00	Dec 30 '00	0 days					●				
TRIG	ML2	QT-1001	Finish Trigger Final Prototype Design	Dec 30 '01	Dec 30 '01	0 days						●			
TRIG	ML3	QT-1329	CSC: Bckpl Specified (DT Info)	Dec 30 '01	Dec 30 '01	0 days						●			
TRIG	ML3	QT-1216	RCT: CCC Prototype Test Complete	Jun 30 '02	Apr 30 '03	206 days							●		
TRIG	ML3	QT-1219	RCT: RC Prototype Test Complete	Jun 30 '02	Feb 28 '03	163 days								●	
TRIG	ML3	QT-1215	RCT: ASIC Prototype Test Complete	Jun 30 '02	Jun 30 '03	249 days									●
TRIG	ML3	QT-1220	RCT: Bckpl Prototype Test Complete	Jun 30 '02	Jun 30 '03	249 days									●
TRIG	ML3	QT-1222	RCT: Electron ID Prototype Test Complete	Jul 30 '02	Feb 28 '03	142 days									●
TRIG	ML3	QT-1235	GCT: System Design Complete	Aug 30 '02	Dec 8 '02	71 days									●
TRIG	ML3	QT-1221	RCT: JSC Prototype Test Complete	Sep 30 '02	Jun 30 '03	184 days									●
TRIG	ML3	QT-1335	CSC: Clock & Control Board Prototype Test Complete	Sep 30 '02	Dec 8 '02	50 days									●
TRIG	ML3	QT-1226	RCT: CCC Production Test Complete	Mar 30 '03	Nov 30 '03	175 days									●
TRIG	ML3	QT-1337	CSC: Muon Port Card Prototype Test Complete	Mar 30 '03	May 30 '03	44 days									●
TRIG	ML2	QT-1002	Finish Trigger Final Prototypes	Apr 30 '03	Jun 30 '03	43 days									●
TRIG	ML3	QT-1336	CSC: SR/SP Prototype Test Complete	Apr 30 '03	Jun 30 '03	43 days									●
TRIG	ML2	QT-1004	Finish Trigger Pre-Production Design & Test	Jun 30 '03	Jun 30 '03	0 days									●
TRIG	ML3	QT-1338	CSC: SR/SP - MPC - C&CB Test Complete	Jun 30 '03	Jun 30 '03	0 days									●
TRIG	ML3	QT-1229	RCT: RC Production Test Complete	Sep 30 '03	Sep 30 '03	0 days									●

Prototypes performed sufficiently to serve as pre-production

Production will proceed on schedule



US Trigger Project Resources



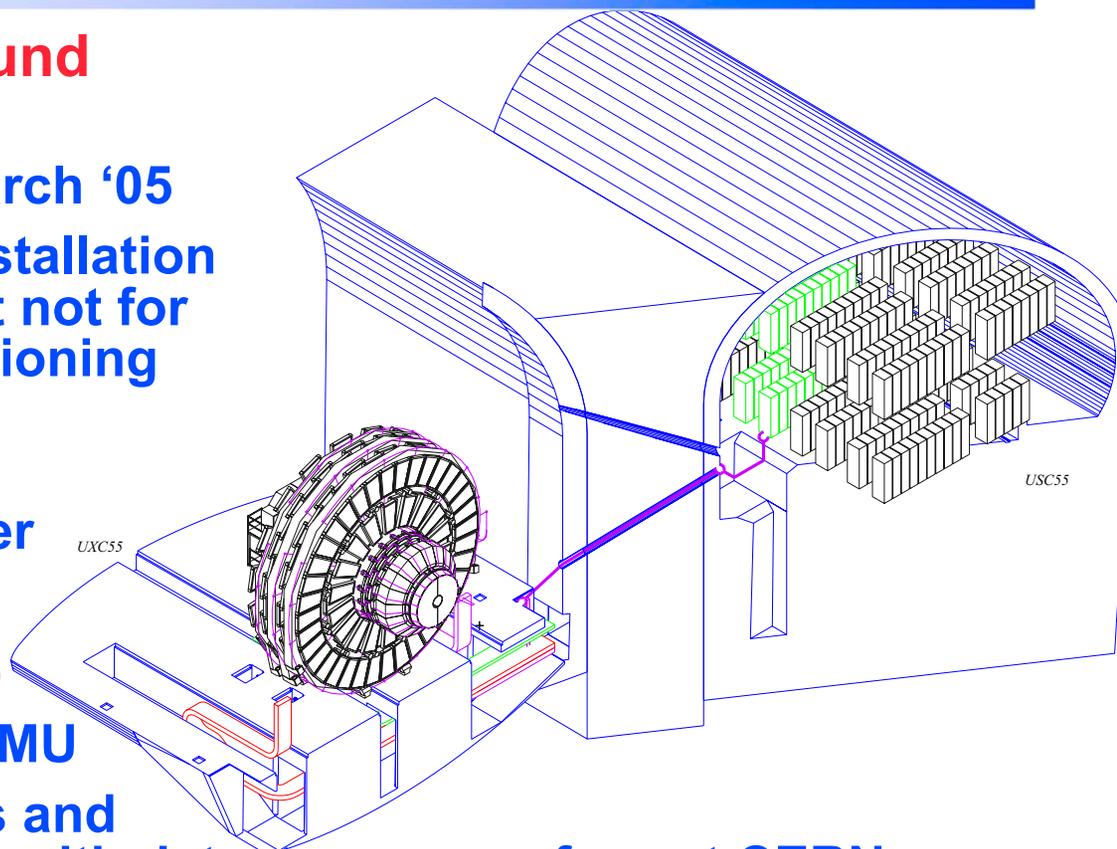
Engineering demand remains significant thru installation & commissioning start



Trigger Transition to M&O

Installation in Underground Counting Room

- Expect access by March '05
- Sufficient time for installation and some testing but not for completing commissioning with detectors
- Need to start commissioning earlier



Slice Test (on surface)

With Both HCAL and EMU

Verify trigger functions and interfaces by testing with detectors on surface at CERN.

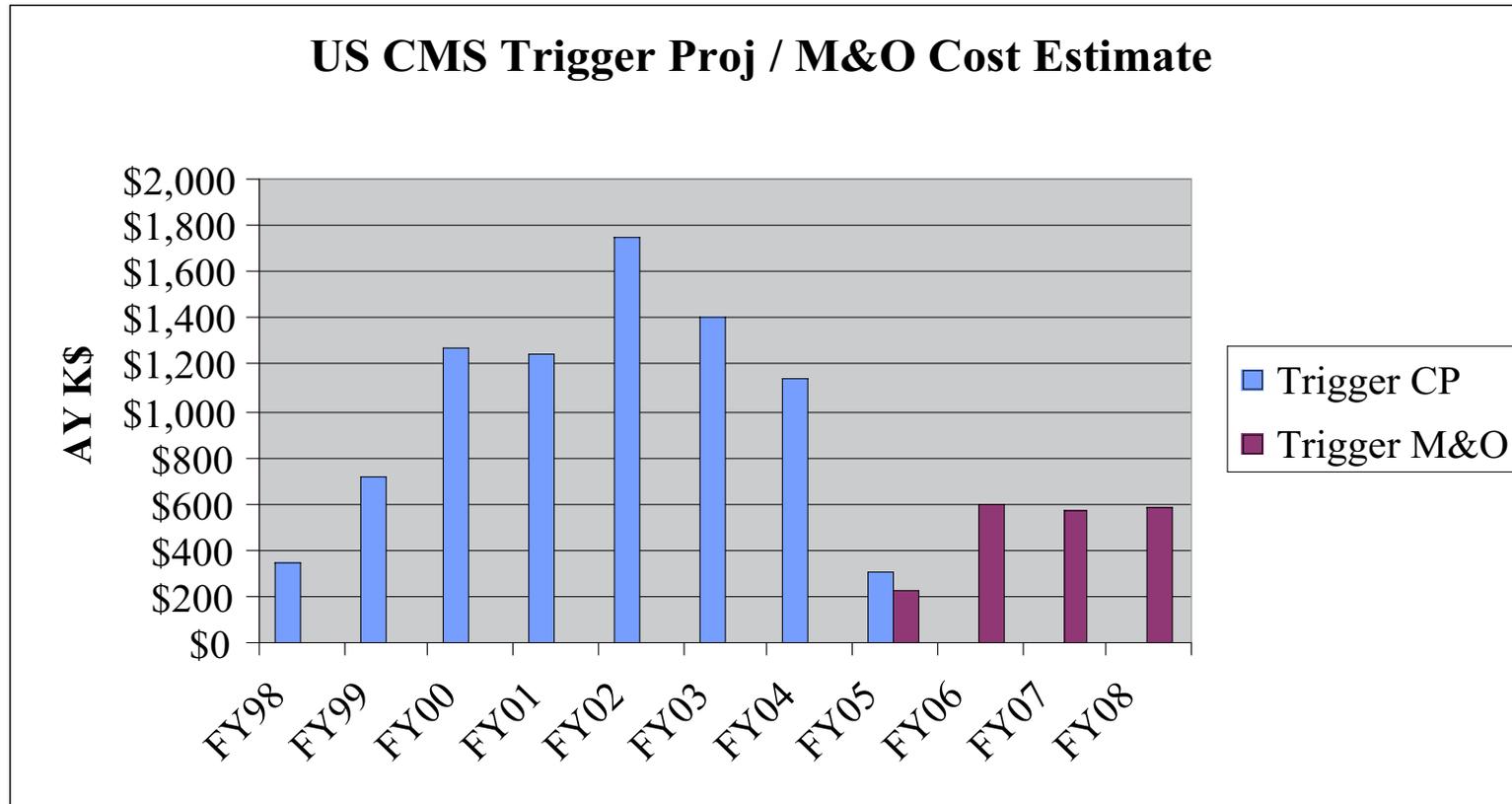
Use as substitute for commissioning completion step.

Will check as much on surface before gaining access to underground facilities.

Milestone (HG1018) planned for completion November '04



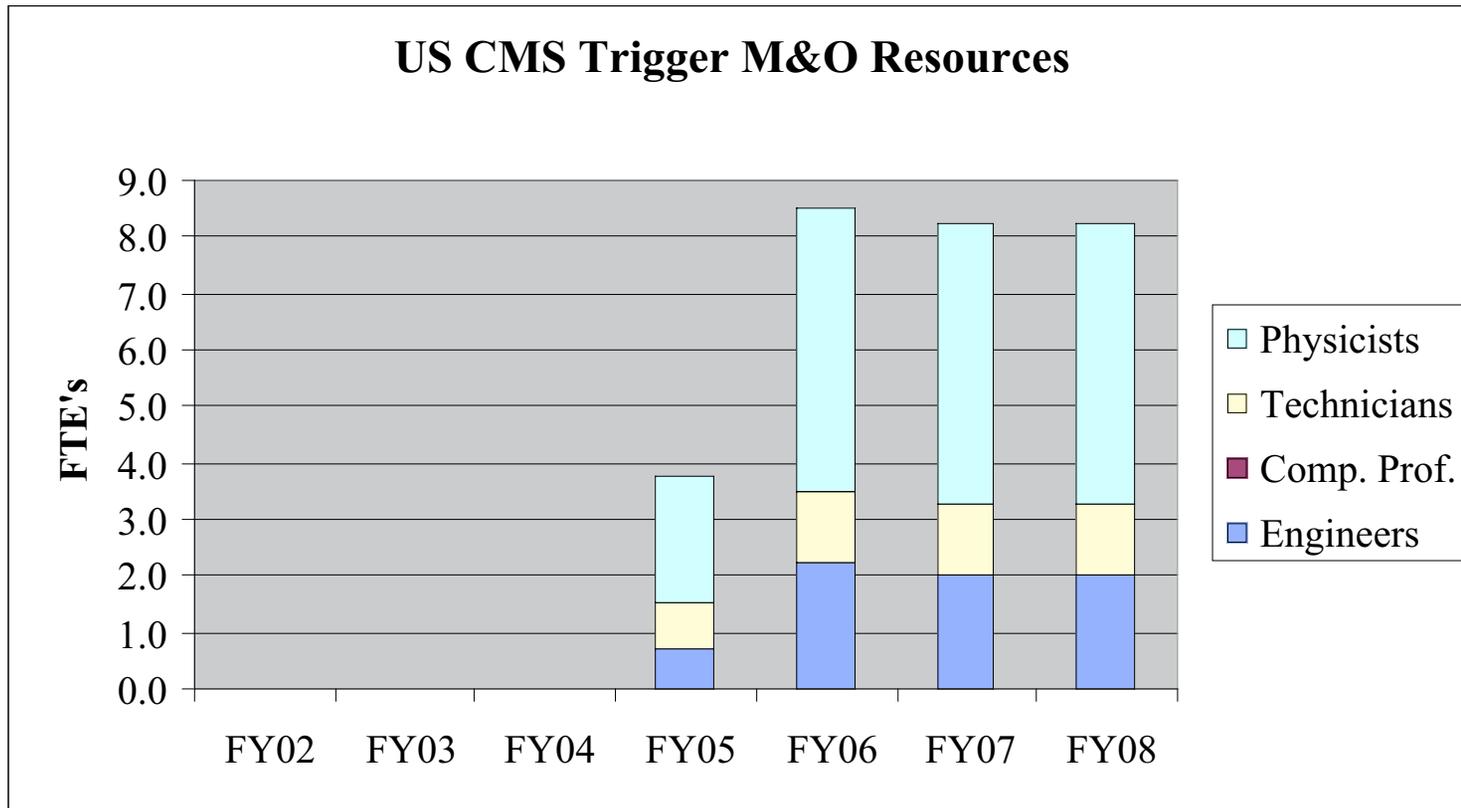
US Trigger Transition to M&O



**Production ordering underway.
M&O starts with slice test**



US Trigger M&O Resources

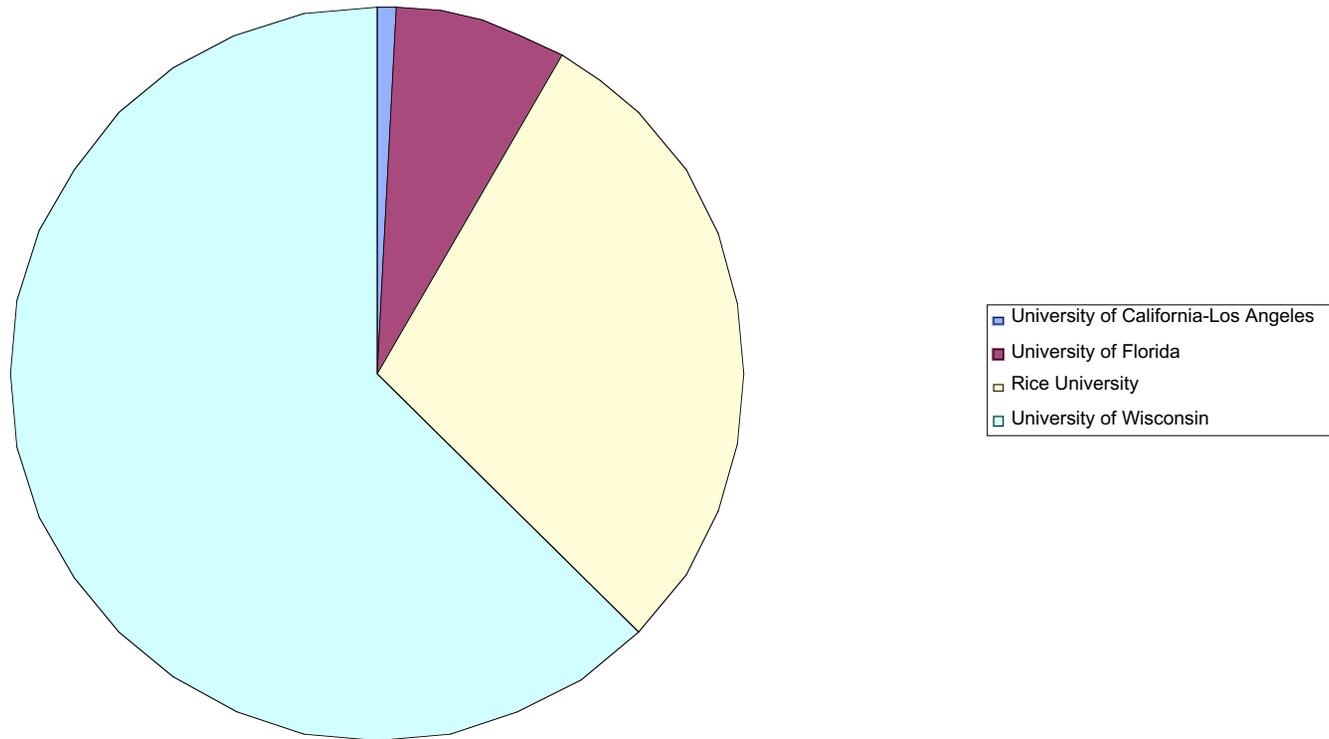


**Testing & Operation of Trigger System
Changing conditions \Rightarrow modifications**



US Trigger FY03 Planning

Trigger SOWs FY03 -- \$1.3M AY



**Largest costs: production parts orders
Engineering costs for testing/final revisions**



Concerns

Installation Schedule

- Time for installation & commissioning tight (sched. delay)
- Significant time needed for integration in a synchronous pipelined system
- Use slice test to advance installation & commissioning

Base Program Manpower

- Major effort on trigger software required
 - Tasks include board testing, monitoring/controls, diagnostics, configuration downloading and documentation, modeling, physics simulation, etc.
- Major effort on testing & installation
 - Planned as activity of base program manpower
- New Major Effort on “Slice Test”
 - Also needs base program manpower
- Recent DOE University program augmentation is a big help



Conclusions - Trigger

Calorimeter Trigger

- All Preproduction Boards tested
- Production started
 - Most parts ordered, ASIC production finished
- Integration tests: ECAL started, HCAL starts this Fall

Muon Trigger

- All Pre-production boards built & under test
 - Basic stand-alone tests complete
 - Integration testing between boards has started
- Integration tests starting this month w/EMU
 - Operation in 25 ns structured beam

Project Completion

- Transition to M&O
- Slice Test